Menlo Park Notebook #115 [N-80-07-19]

This notebook covers the period July-October 1880. The entries are by Charles L. Clarke. The book contains calculations, notes, and drawings relating to the electric railroad, especially the design of the locomotive. There are also four pages of notes and calculations about copper conductors and two scaled template patterns for dynamos. The label on the front cover is marked "C. L. Clarke." The book contains 284 numbered pages.

Blank pages not filmed: 142-279, 284.

xE.172
N-80.07.19

What resistance of lamps.
What do for field magnet.

1/100. 100 feet

Clark

16

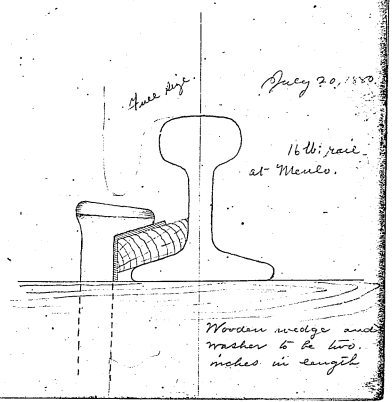
1

Electric Locomotive.

July 17, 1880.

Head light.
Whistle.
Brakes.

Clarke



July 20, 1885. Clarke,

A standard light passenger car on the Penn. R.R. weighs 39300 lbs. and carries 54 passengers.

Speed 30 m. per hour
or 2640 feet per m.
If we take a ton as 2000 lbs. and resistance as 10 lbs. per ton, each ton will consume 2640 × 10 = 26400 ft. lbs. per min. at speed of 30 miles per hour. Each car (20 tons) would therefore require 26400 × 20 = 528000 ft. lbs. = 16 H.P.
Suppose the passengers to average 150 lbs. weight, the total will be 54 × 150 = 8100 lbs = 4 tons
The power consumed due to passengers will be 26400 × 4 = 105600 ft. lbs. = 3.2 H.P.
The H.P. required per loaded car will be 19.2 H.P.

om

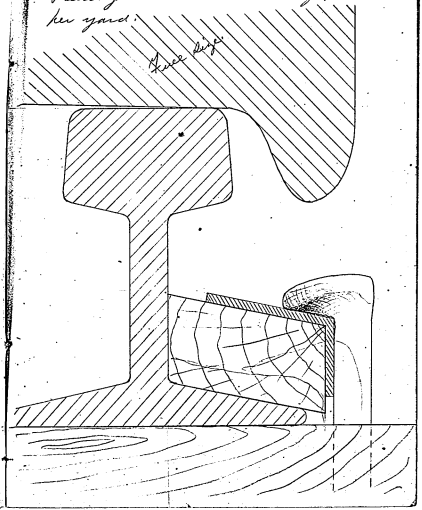
16/100 16/65·00 16)65·00(4·06
52,8 .04 2,112 52,8 .04 2,112

The entire weight of one loaded passenger car is 24 tons and the resistance due to that car is (24 × 10) = 240 lbs.

5 cars would require (19.2 × 5) = 96 H. P. and a resistance of (240 × 5) = 1200 lbs. and if only one tenth of the weight on driving wheels is the adhesion (adhesion being as high as one fifth or even one third under most favorable conditions of track and weather) the required weight is 1200 × 10 = 12000 = 6 tons.

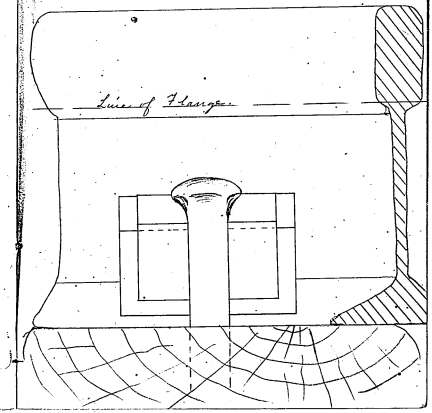
July 21st 1880. Clarke, 7.

Standard steel or iron rail on Pennsylvania R. R. weighs 67 lbs. per yard.



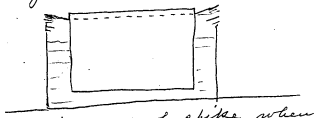
July 21st 1850. 9

Clarke.

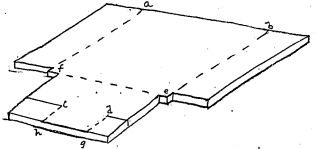


Clarke.

Instead of making the angle-washer shorter than the wooden insulation, thereby crushing into the wood on account



of pressure of spikes when the rail buckles in the passage of a heavy load, it may be cut in this shape and then is to be

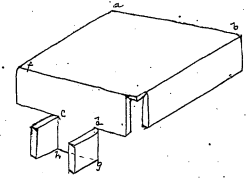


bent along the dotted lines

as shown below. The wooden insulator and angle washer are thus

July 21, 1860. 13

Clarke



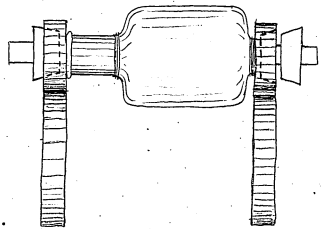
held immovable by the spike.

If the wood be two inches long there will be four square inches bearing on the flange. I think it advisable to make it three inches in length.

Even if not thought desirable to flange the angle washer it out to have a length equal to that of the wood.

Electric - locomotive. June 21, 1880.

Clarke.



Electric Locomotive — July 21, 1880.

Clutches.

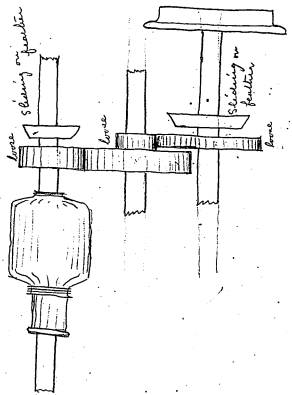
Spur wheels set loose; one clutches sliding on feather.

Pulley on gear

Pinion on gear

Electric locomotive. July 22, 1890. 19

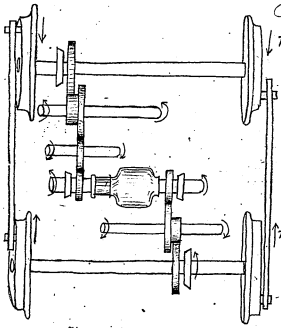
Clarke.



Electric Locomotive, July 22, 1895.

Crank.

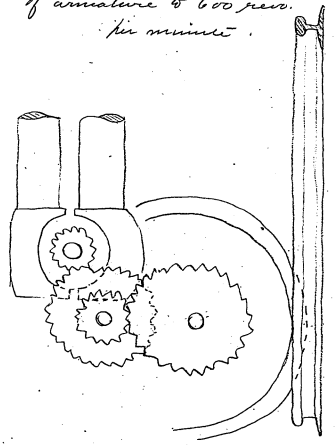
When in gear.



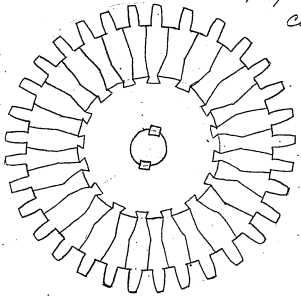
When in gear.

Spur wheels loose, Core clutches sliding on feather.

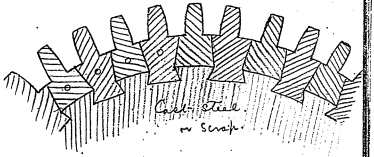
Reduce the constant speed of armature to 600 revs. per minute.



Electric Locomotive. June 22, 1885. 25
Clamton

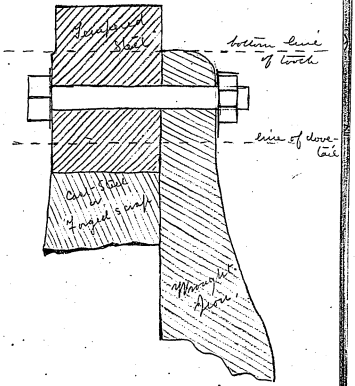


Tempered steel teeth.



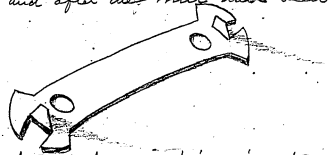
Electric Locomotive, July 23rd 1888.

Section of tooth showing Cam Key fastening

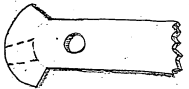


Electric Locomotive, July 22, 1889.

Each pair of bolts will be connected by a double washer and after they must have been



turned home a piece is cut out as shown in figs. and bent up, thus locking the nuts.

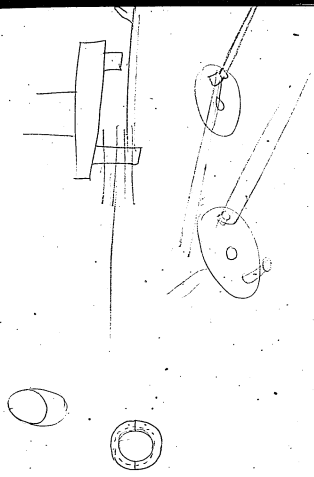


The same arrangement is to be on the bolt heads on opposite side.

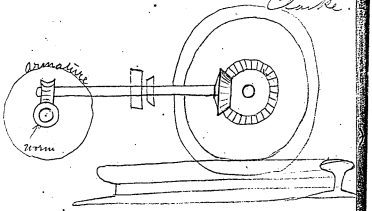
Electric locomotive, July 23 31, 1880

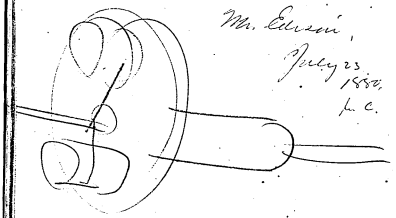
Same size as the Clarke,
120 H.P. dynamo-electric
machine.

Weight of Fields	3324 lbs.
Brass Field Plate	300 lbs.
6 Cores	3108 lbs.
Copper wire	804 lbs.
Hearts	2160 lbs.
Armature without shaft	2487 lbs.
	12183 lbs.

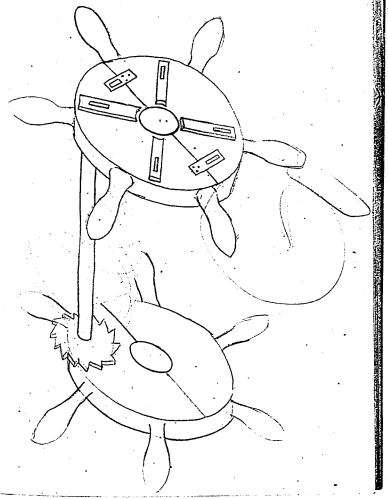


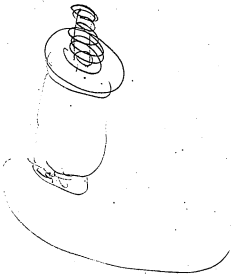
Electric locomotive. Jules 35
1880.
Clarke.



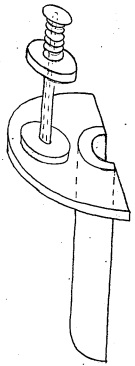


M. Edison,
July 23, 1880.
L. C.



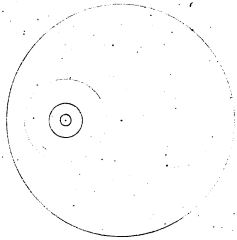


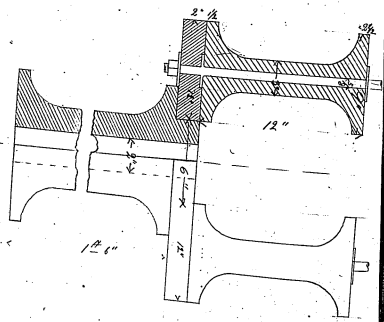
Sewing Machine, June 23, 1850, Clarke.



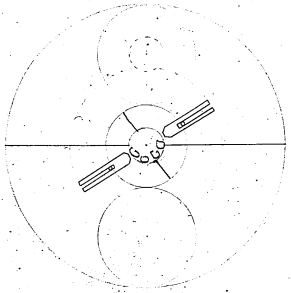
Sewing machine, July 23 1850, Clarke

41



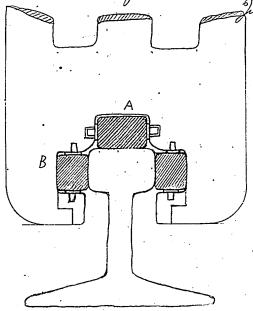


Sewing Machine. Scale 2" = 1ft. Patent 1850, Clarke.



Roller clutch for climbers. July 26, 1880

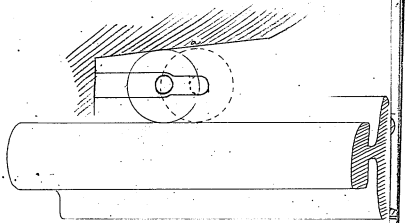
Clarke.



Cross-section showing the top roller which is simply to prevent sliding friction when clutch moves forward. Side rollers clutch.

Roller clutch, July 26, 1880. 47

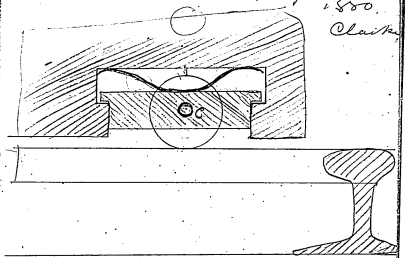
Clarke.



Plan of clutch rollers on side of crank head, showing the guiding groove for axles, which groove takes the axles after the pressure is off and prevents sliding friction at a: and also limits the play of the rollers.

Roller clutch. July 26. 1900. 49

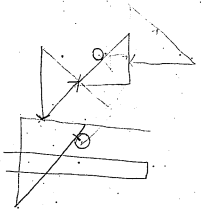
Clark.



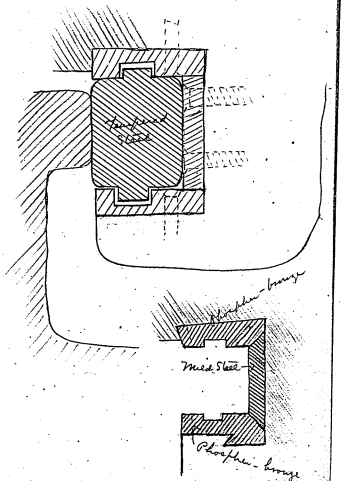
The anti-friction roller on top of rail. When the clutch rollers tighten and thus as a fulcrum would tend to bring a pressure on the axle C the spring allows the rail and shoe to come in direct contact with roller, thus preventing strain on C.

60 120
20 25

6
36 81
36
3
108
81
2
162

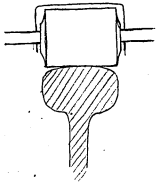


Roller clutch, July 26, 1880. 51
Clarke

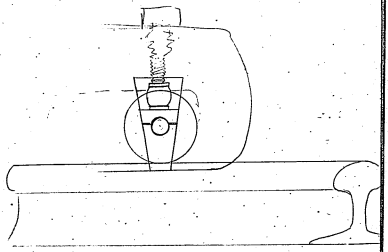


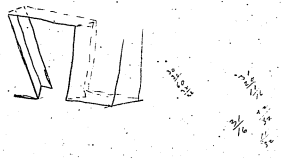
Roller clutch. July 26, 1880.

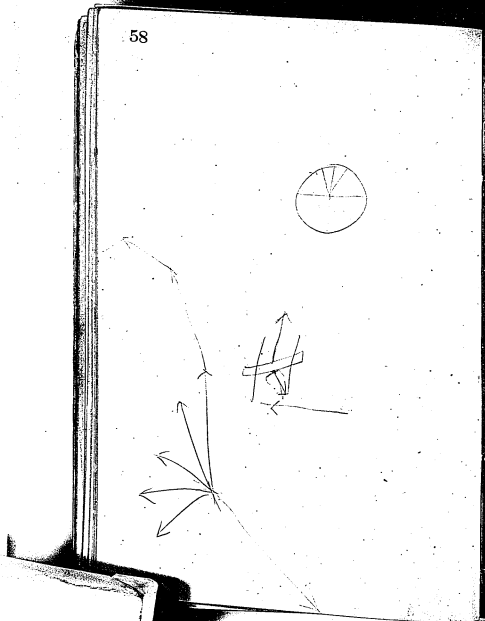
Roller clutch. July 26, 1850, 55
Clarke.



Roller clutch, July 26, 1859
Clarke







Efficiency of the worm
on 1st geared locomotive
1½ pitch, 7½ pitch diam.

July 27, 1910
Clarke

3.14
7.5
1570
2198
1.5 | 23.55 (15.7 nat. tan. of θ.
15
85
75
105

Angle 86° 21'
3° 40'

θ − φ = 86° 21' − 4° 18' = 82° 3'

$\frac{1}{\tan\theta}$ = .0636

15.7 | 1.000000 (.0636
942
580
471
1090
942

$\frac{1}{\tan(\theta-\varphi)}$ = .1396

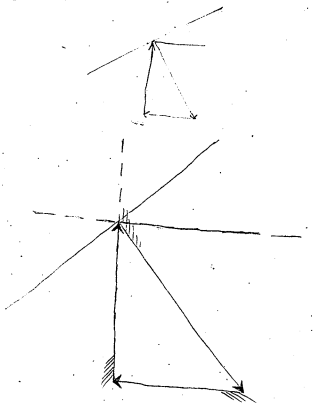
7.1607 | 1.000000 (.1396
716 07
2839 30
2147 21
691 6090
644 463
466 270

$\frac{\tan\theta}{\tan(\theta-\varphi)}$ =

7.1607 | 15.7000 (2.1925
14321 4
1378 60
1160 7
2182 50
2147 21
1806 70
1432 14
3745 60
3580 35

2, 1925 is the
Counter efficiency

See Engineering Vol. XIX, No. 473. pages 73+74.
Jan. 22. 1875



This is upon the assumption that the angle of friction is 4°18' or its tang. and coeff. of friction are .075.

If we suppose the coeff. to be only .05 the angle of which is 2°52'.

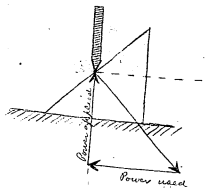
then $\theta - \phi = 86°21' - 2°52' = 83°29'$

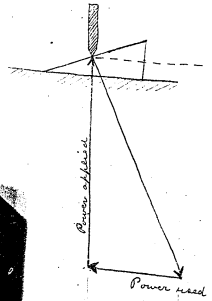
$$\therefore \frac{\tan\theta}{\tan(\theta-\phi)} = \frac{15.7}{8.754} =$$

8.754) 15.7000 (1.7935
8 754
6946 0
6 129 78
8160 20
7 877 86
282340
262262
20780

1.7935 is Counter efficiency.

1.47) 1000 (.70
179) 1000 (.60





In unusually favorable the coeff. of friction has been (Rankine) as low as .03

Angle of .03 = 1°43'

Then $\theta - \varphi = 86°21' - 1°43' = 84°38'$

$\therefore \frac{\cos\theta}{\tan(\theta-\varphi)} = \frac{15.7}{10.65} =$

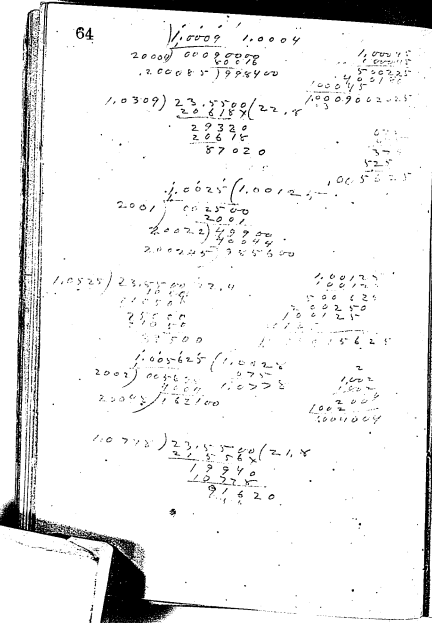
10.65) 15.70 (1.474
10 65
5050
4260
7900
7455
4450
4260
1900

Counter efficiency

When coeff. of friction is .03
1.474

When coeff. of friction is .05
1.7935

When coeff. of friction is .075
2.1925



If p = pitch
r = radius of pitch circle
f = coeff. of friction
then the counter efficiency will be least possible when

$$p = \frac{2\pi r}{f + \sqrt{1+f^2}}.$$

The economical angle is given by formula

$$\tan\theta = \tan\phi + \sqrt{1+\tan^2\phi}$$

Where θ is the angle which thread makes with axis of screw and ϕ is the angle of repose.

Data in present case $2\pi r = 23.55$"

When $f = .03$

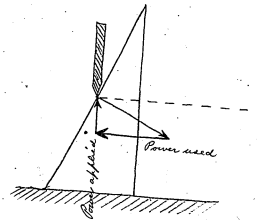
$$p = \frac{23.55}{.03 + \sqrt{1.0009}} = \frac{23.55}{1.0309} = 22.8$$

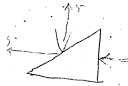
When $f = .05$"

$$p = \frac{23.55}{.05 + \sqrt{1.0025}} = \frac{23.55}{1.0523} = 22.4$$

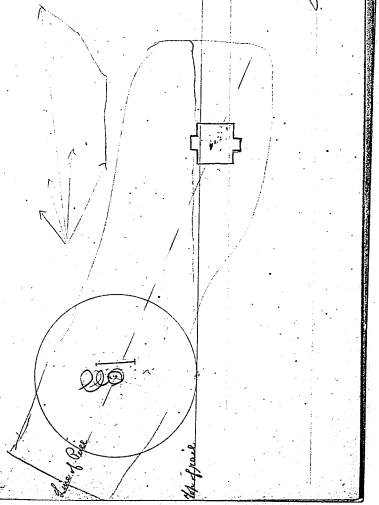
When $f = .075$"

$$p = \frac{23.55}{.075 + \sqrt{1.005625}} = \frac{23.55}{1.0778} = 21.8.$$





Roller clutch, July 27, 1869. 67
Charles



July 27. 1848

14" dynamo machine

Diam. of iron plates 14".

51 Commutators.

102 notches.

404 turns.

.431" by 1 inch.

.030" for peg.

.401" for wire.

4 wires in each notch side by side.

Each wire .100" diam. including covering.

.013 allow for covering.

Actual diam. of wire .087"

Contains 7570 circular miles.

And 8 contains 60560 c. miles.

Dimensions of Armature

9/5.4
.6
.8
1.48

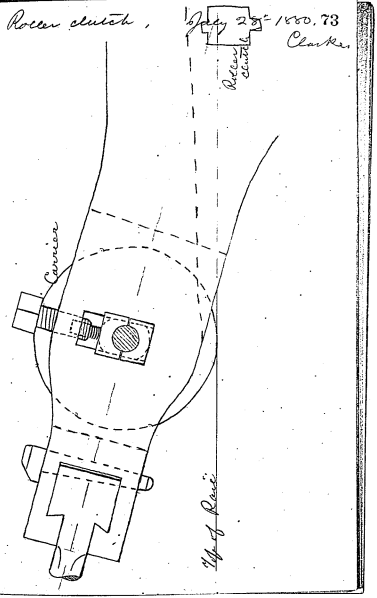
4/3.6
.9

Armature 20" long.
14" diam.
34"
2
68" Distance around
6" for ends
74" Total
102 turns
14 8
74
12/75.48 Inches of wire
4/6 2 9 feet "
157.2

Resistance of machine .0244 ohm

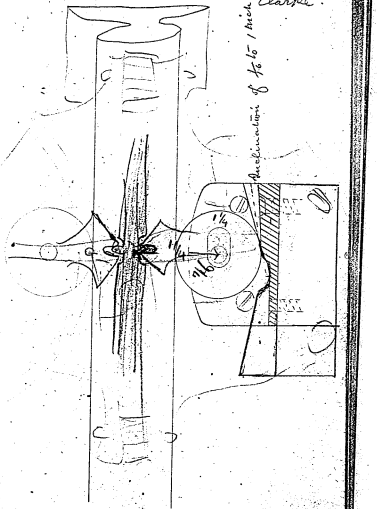
Dimensions of Armature.

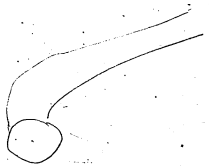
Roller clutch.



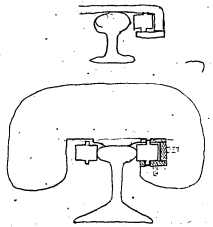
Roller Clutch, July 25, 1880

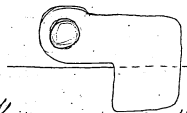
Specification of No 16, Mech. Clarke



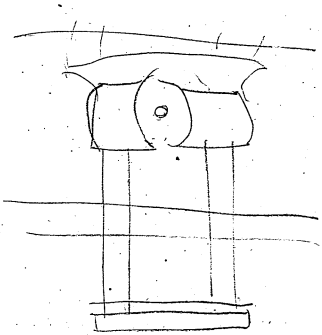


Roller Clutch. July 28, 1880, 77
Clarke.

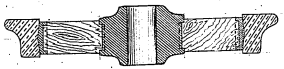




The model was made in wood by John Catt and tested July 29th, 1880. Worked very satisfactorily.

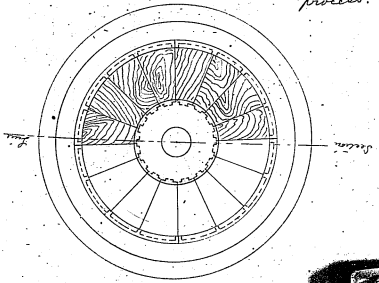


Creasing locomotive.
Improved car wheel July 29, 1890,
Clarke.



See page 89.

Why not use wood
treated by the creasing
process?

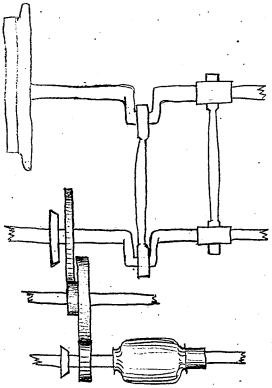


Electric Railway. July 30, 1880.
Clarke.

Instead of having the motor's gear directly into a spur wheel on the driving wheel axle (for then we cannot place the locomotive on springs must must have everything rigid, which will strain all the parts and must frequently break the axles) I propose to gear to an intermediate shaft and connect this shaft with driving wheel shaft by connecting rod and thus take up the motion and place locomotive upon springs

over

Electric Railway. July 30, 1880 85
Clarke.



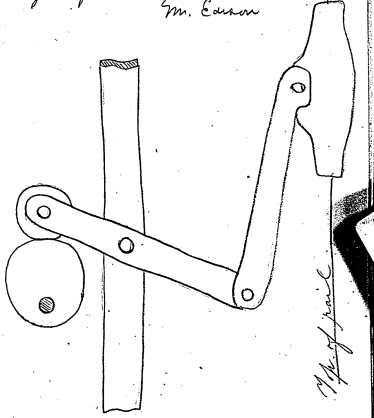
Two rods at right angles may be used as in fig.

Electric Railway, July 30, 1880.

Clarke.

Cam gear for creeper

M. Edison

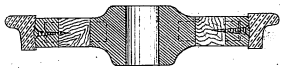


How it is to be brought back excepting by a spring.

See page 93

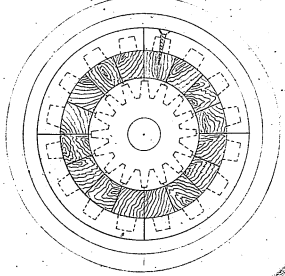
Electric Railway, July 30, 1889

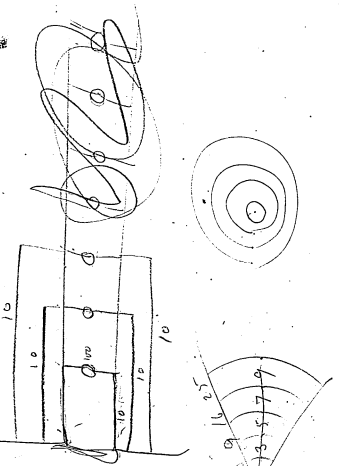
Insulated Car wheel. Clarke.



Allow a clearance between each metal and tenant. See page 81

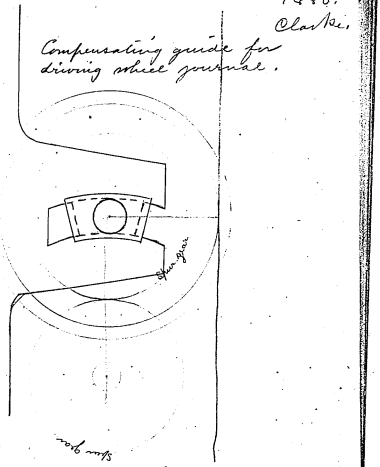
Wood screws or dowels driven into wooden spokes.



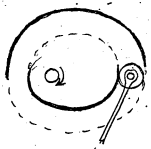


Electric railway. July 30, 91
1000.
Clarke.

Compensating guide for driving wheel journal.



Electric Railway. July 30th 93
1850
Clarke.
See page 8-7.

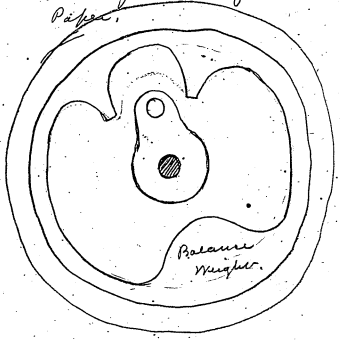


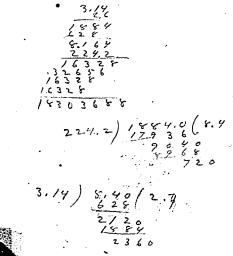
By having an inside and outside arm the bumper can be pushed forward by doing away with the spring.

Electric Railway, July 3/21-95
650
Clark

Electric Railway. Aug 2, 1880.

Driving wheel of Clarke Papa.





Weight of armature with
copper 2500 lbs.
Fields 3324 lbs.
Cores 3108 lbs.
Wire 800 lbs.
Heads 2160 lbs.

11900 lbs.

Aug 2. 1880
Clarke

3.14 × 5.5 = 17.27
5280 × 3 = 15840
15840 / 17.27 = 224.2 turns of driver

40 m. per hr = 2/3 m per min.

4 Omiles per hour

Wheel on armature plunger-
1' diam.
600 revo. per m.
Circum. 3.14 ft.
Circum. velocity 1884 feet per m.

Spur on driving wheel
diam 2.6 ft.
Revo. per mile 224.2
Circum. 8.16 ft.
Circum velocity 1830 ft. per m.

If a maximum of 200 H.P. is ever required at 40 miles per hour,

We have 66,000,000 ft. lbs. per minute.

Speed 35·20 ft. per m.

Therefore pressure on teeth of spur wheel at armature is

3520) 66,000,000 (1875

3520

29500

28160

26400

24640

17600

17600

= 1875 lbs.

If same H. P. is developed at speed of ten miles per hour we have speed per minute = 5280 = 880 ft., and pressure on spur wheel is

880) 66,000,000 (75·00 = 75·00 lbs.

6160

4400

4400

We will then consider
10 000 as the greatest strain
coming on the teeth of the
open wheel on armature shaft.
According to Fredgold the stress
should never be greater than
4500 lbs. per sq. in. of
section across the tooth

and the tooth should
be broad enough across
the face for the same reason.
This is for cast-iron
If then we make the gears of
steel we certainly can assume
2½ sq. in. as safe.

36) 37.6992 (1.0472
36
169
144
259
252
72
72

3.1416
15
15708
31416
47.1240

24) 37.6992 (1.57
24
136
120

36) 47.124 (1.31
36
108
108
32

12 : 21 :: x : 31

31
21) 372 (18
21
162
31
93

21
63

93 : 600 :: 63 : 600 (406
93
372
600
558
42

Diam. of gear 1ft
Circum. 3.1416 ft.

If Three pitch then
36 teeth
Circum. pitch = 1.0472"
Will not give cross-section enough

If 2 pitch then
24 teeth
Circum. pitch = 1.5"
Not cross-section enough.

Diam. of gear 15 in
Circum. 47.124 in

If 3 pitch then
36 teeth
Circum. pitch =

Not applicable

3.1416 × 1.5 = 4.7124

7 × 12.5 = 84

84 : 225 :: 2.5 : 6.7

84 / 562.5 (6.7

6.70 (2

84 : 180 :: 2.5 : 5.36

84 / 450.0 (5.35

7 : √84 :: x : √2.5

84 / 217.5 (2.59

84 / 300.0 (3.57

1.2 : 7 :: x : 12

x = 2.06

5.68

36) 56.8 (1.58

36

208

180

280

252

28

15/32 = .468

15/180 = .083

2.5 − 2.1 = .4

1/2.5 = .4

3.0 − 3 = .0

15

8

7

2.5

84 : 180 :: 2.5 : 5.36

1.5

3.6

1.2

7 : 84 :: x : 2.5

2.5

7

5.

2.5

7

2.1

70

2.5

84

1.55

9.17 / 11.00 (1.2

9.17

1800

1834

166

1.2 : 7 :: x : 12

x = 7 / 9.4

9.06

If armature be increased to 107 31 inches and gear to 1'6" then when

3 pitch

54 teeth

Circum. pitch = 4.7 ft. = 56.8"

= 1.58

2 pitch

36 teeth.

The pitch in order to get a tooth of the proper cross section should have circum. pitch of 2.6", which means a width of tooth 1.2 and height 2.06 giving cross-section of 2.47 sq. in.

~~If~~ If we assume 2 sq. in. for pitch

1.414

9.17 / 9.800 (1.07

917

883

1.414

1.414

9.17 / 12.970 (2.3

917

534

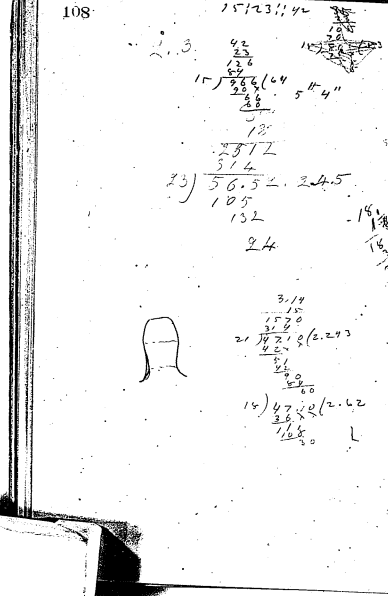
458

760

9.17 / 6960 (1.85

7338

462



Diam 2.3"
2 Pitch
Teeth 36

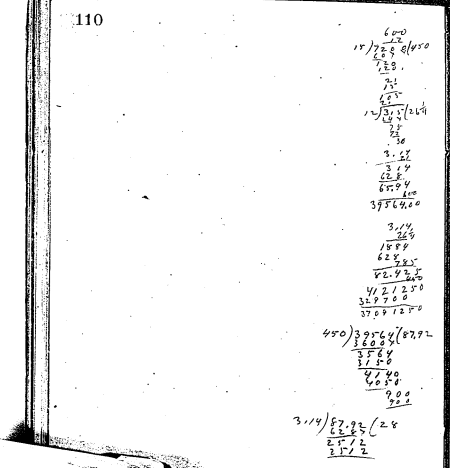
Diam 18"
2 Pitch
Teeth 36

Diam 20"
2 Pitch
Teeth 40

Diam 24"
2 Pitch
Teeth 48"

Beam

18"



3.1416 / 18

25 / 13 28
31 4 16

24) 56.5 4 8 8 (2.356
48
85
72
138
120
18

18) 24.0 (1.3
18
60
54

1.3) 24.0 (18.5
13
110
104
60
52

18.5
1.3
74 0
185
259 0

18.2
1.3
900
182
27.

18.5) 26 (1.4
185
7500
7400
100

Aug 3, 1850.

3.1416)

23
24
92
46
552.000 (175
31416
237840
219912
17928 0

15" spur. 1.2 diam. pitch.
18 teeth. 2.6 circum. pitch.
Armature 21" diam. at 600 revo.
with spur of 12"
~~15 : 12 :: 600 : 750~~ ~~Revo. per min~~
~~Mult 10 : 100 :: 21 : 210~~ ~~diam of armature~~

aug 3. 1880

3.14
15
1570
314
471

1800
12
21600

21600.0 (458.6 revo. to give
1885 x x
2760 1800 ft. circum.
2355
4050 velocity per in.
3768
2820 in 15" spur.
2826

3.14
21
314
628
659.94

600 revo.
458.6) 39564.00 (86.27 circum. of Armature
3468 5 x x to make 458.6 revo.
2877 60
2771 6
12499 0
9172
32680
32102

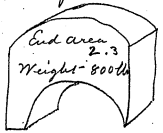
3.14) 86.27 (27.4
628 x
2347
2198
1490
1256
2340

27 3/8

27 3/8 diam of Armature
to make 458.6 revo.

See Book 72 First Series pages 186 to 194. Aug 3, 1880

Motor for Locomotive.



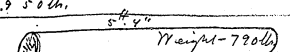
One magnet-field.

Weight-of 6 = 4800 lbs.

27" Dynamo.

2.3
57
161
1771
4800 lbs.

8855 50
7085
7940 50 lbs.



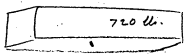
~~2.75~~ $3\frac{9}{12} = \frac{45}{12 \times 12} = \frac{45}{144}$ .3125

144) 45.0 (.3125
432
180
144
360
288
720
720

1.636
4800
13088
6544
7852.80

.3125
.3125
15625
6250
3125
9375
.09765625
3.14
39062
29297
.30677 5/8
153389
10225 9

Weight of 6 = 47140 lbs. 1.636149



Weight of 3 = 2160

3.5 : 5.33 :: 133.7 : 204

6685
4456
3.5 / 713.7 (204
700
137
140

Copper wire on each core
200 lbs.
6 Cores = 1200 lbs.
Cores + copper 5940 lbs.

Armature for 20½ Magnet
weighs 2187 . Plates are
20." diam.
Now for 27" diam

$20^2 : 27^2 :: 2187 : 3986$ lbs.

729

27
27
189
54
729

19683
4374
15309
15943
3986

Weight of Armature Plates
3400 lbs.

19000 · 50 = 95000 · 10

50 · 10 = 500

Suppose Copper (300 lb) & Armature in same ratio,

400 : 729 :: 300

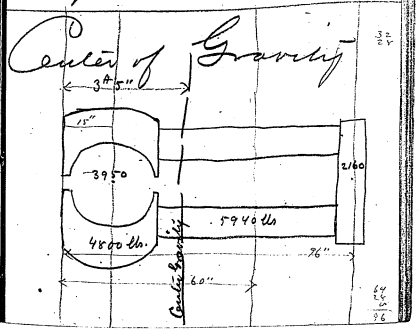
729 / 300

400 / 218700

547

Copper on Armature 550 lb.

Armature & Copper without shaft - 3950 lb.



48500
3950
87550
15
437500
8750
131250

5940
60
356400

2160
96
12960
19440
207360

48500
3950
5940
2160
16850

131250
856400
207360

16850) 695010 (41.
67400
2101
1685
4160

41 miles = 3 # 5"

See Recd. per minute of 5 ft- page 113 driver at- 90 miles per hour is 224.2 and at- 1800 feet- speed of gearing or 21600 inches the circumference of wheel should be

224.2) 2160000 (96.34 inches on circumference
2017 8
142220
134552
76500
67226
9274 0
8 9 6 8
38720
33642
5078

3.1416) 96.3436 (30.7 inches
94 24 8X
2095 60 = diameter
of spur.

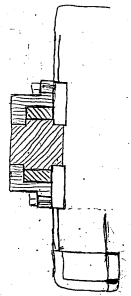
1.2 was diam. pitch of
spur on armature shaft-

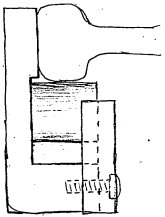
30.7 / 1.2 = 36.84 ; 30 / 1.2 = 36.0 teeth and
spur on driving wheel
30 " diam.

2	2	500	175
2	4	675	
3	7	850	175
2	4		
	11		3 1 0
3	5		1 2 5
1 1 5	16		4 5 0
	6		1 3 7 5
	22		
	7		

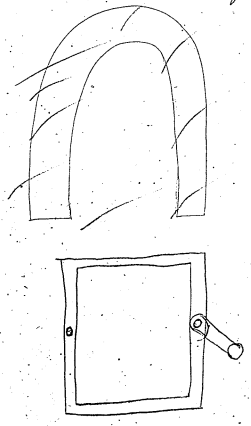
Aug. 7th 1880.

Clutch. Clark.





Reversing gear for Clarke's clutch,
Aug. 9, 1880,



2) 3.1416
1.5708
4
5.5708
.02
.111416

Length of Dividing Line

3.1416
17
2
.142832

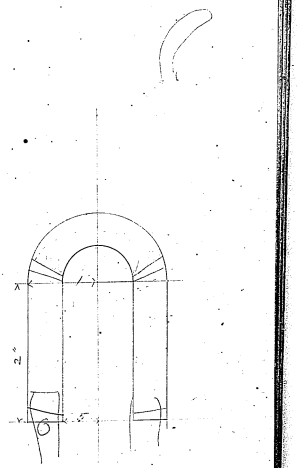
Length of Circumference

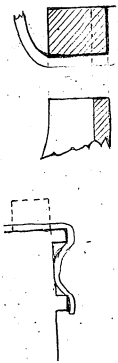
5.5708 : 7.1416 :: .111416

7.1416
.111416
71416
71416
71416
71416
71416
7.957656 ÷ 5.5708 = 1.42

5.5708
.111416
3.14) 5.959384 (1.74
3.14
2879
2198
1213

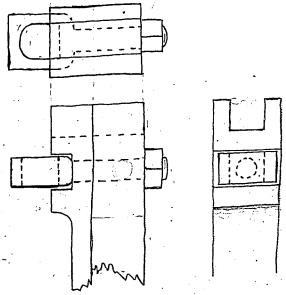
7.1416
.142832
3.14) 6.99857 (2.23
628
370
314
56





Aug. 12, 1880.

Clarke



10.64
.0024
305733) 0.0732576 0000000137
305733
1198670
917199
281471 0

.000000014 ohm

and if we take the 12 lines as great resistance

we have .000000014
12
.000000168 ohm. and
for 138 connections 138
1344
504
168
.0000231864 ohm

~~Internal~~ Cor. 4th Church.

Resistance of conductor of copper .24" × 1" and $\frac{1}{500}$" long.

$R = \frac{10.64\ z}{m}$, when z = length in feet and m = circular mils

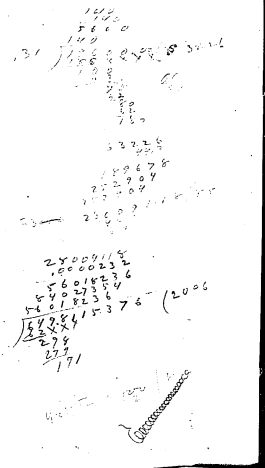
1 circular mil = .0005^2 × 3.14
= .000000785

3.14
.000000 25
15 70
62 8
.00000 0785 0

.000000785) .24000000000 (305733
23 55
4500
3925
5750
5495
2550
2355
1950

There are 305733 circular mils in this section .24 × 1.
Length is .005" or .0004 ft.
hence $R = \frac{10.64 \times .0004}{305733} =$

Resistance from solder
.0000232 ohm



If resistance be 305 / and internal is .01 ohm. then
Efficiency is .3 ohm and total .31 ohms. with 140 Volts we
.31 ohms we have

$\frac{140^2}{R} \times 44.3 = 28009118$ ft-lbs.
$= 85$ H.P.

Now of the total 28009118 ft-lbs.
.0000232 is due to soldering
.31
$= 2096$ ft-lbs.

If soldering be $\frac{1}{1000}$ deep instead of $\frac{5}{1000}$ then the loss is 424 ft-lbs
$= \frac{1}{80}$ H.P.

16
186°

48
215°

16
110 Volts

)26.1) 175.10 (6.7
156
15 4 0

39) 1[illegible]5 (2

6587
.535
32835
32835
3611.85
2278
5890.
71.5
29455
5890
41230

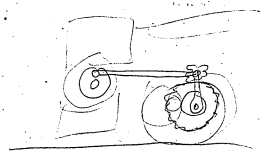
33000) 42 1.1 35.0 (12,76 H.P.
33 x x
91
66
251
231
203

.34
6700
23800
207
227800

1.43
6700
100100
5558
9581.00
6567
1.33
32835
19701
6567
88654.45
9551.
18446
69.5
92230
16601 4
11067 6

33000) 1281.997.0 (38,85
99 x x
296
264
279
246
159

12,76
26.1 H.P.



140
875
700
980
800
97,500

95 Volts at 950 revs. for

19/100 Guarantee.

.28 2.8 ohms to circumference of armature 2.52 4' Commut E.M.F.

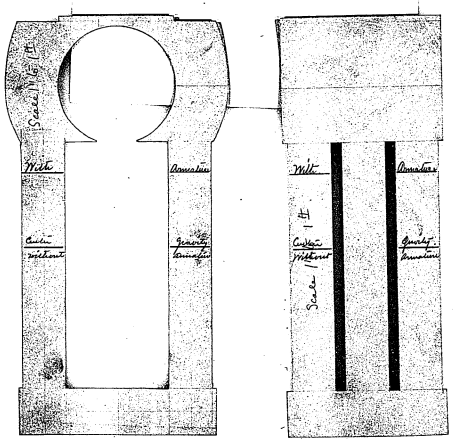
95
35
575
855
902.5
44.3
2707.5
32100
36107.5
2.8) 329980 7.5 - (14 0000

33 000
32
66 000

6.6) 329.5 - (6
322

1/10 of 140000 = 126000
15 000
11000 outside

140 000
16 000
156 000 commut.
11
156

11) 110.000 (7/12
77
330
308
220

[ITEM FOUND IN BOOK]